



[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 23

[Docket No.FAA-2016-9409; Special Conditions No. 23-279-SC]

Special Conditions: Cranfield Aerospace Limited, Cessna Aircraft Company Model 525; Tamarack Load Alleviation System and Cranfield Winglets—Interaction of Systems and Structures

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final special conditions.

SUMMARY: These special conditions are issued for the Cessna Aircraft Company model 525 airplane. This airplane as modified by Cranfield Aerospace Limited will have a novel or unusual design feature associated with the installation of a Tamarack Active Technology Load Alleviation System and Cranfield Winglets. The applicable airworthiness regulations do not contain adequate or appropriate safety standards for this design feature. These special conditions contain the additional safety standards the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards.

DATES: These special conditions are effective [INSERT DATE OF PUBLICATION IN FEDERAL REGISTER] and are applicable on December 23, 2016.

FOR FURTHER INFORMATION CONTACT: Mike Reyer, Continued Operational Safety, ACE-113, Small Airplane Directorate, Aircraft Certification Service, 901 Locust, Kansas City, Missouri 64106; telephone (816) 329-4131; facsimile (816) 329-4090.

SUPPLEMENTARY INFORMATION:

Background

On January 25, 2016, Cranfield Aerospace Limited (CAL) applied for a supplemental type certificate to install winglets on the Cessna Aircraft Company (Cessna) model 525. The Cessna model 525 twin turbofan engine airplane is certified in the normal category for eight seats, including a pilot, a maximum gross weight of 10,700 pounds, and a maximum altitude of 41,000 feet mean sea level.

Special conditions have been applied on past 14 CFR part 25 airplane programs in order to consider the effects of systems on structures. The regulatory authorities and industry developed standardized criteria in the Aviation Rulemaking Advisory Committee (ARAC) forum based on the criteria defined in Advisory Circular 25.672-1, dated November 15, 1983. The ARAC recommendations have been incorporated in the European Aviation Safety Agency Certification Specifications (CS) 25.302 and CS 25, appendix K. The special conditions used for part 25 airplane programs, can be applied to part 23 airplane programs in order to require consideration of the effects of systems on structures. However, some modifications to the part 25 special conditions are necessary to address differences between parts 23 and 25 as well as differences between parts 91 and 121 operating environments.

Winglets increase aerodynamic efficiency. However, winglets also increase wing design static loads, increase the severity of the wing fatigue spectra, and alter the wing fatigue stress ratio, which under limit gust and maneuvering loads factors, may exceed the certificated wing design limits. The addition of the Tamarack Active Technology Load Alleviation System (ATLAS) mitigates the winglet's adverse structural effects by reducing the aerodynamic

effectiveness of the winglet when ATLAS senses gust and maneuver loads above a predetermined threshold.

The ATLAS functions as a load-relief system. This is accomplished by measuring airplane loading via an accelerometer and moving an aileron-like device called a Tamarack Active Control Surface (TACS) that reduces lift at the tip of the wing. The TACS are located outboard and adjacent to the left and right aileron control surfaces. The TACS movement reduces lift at the tip of the wing, resulting in the wing spanwise center of pressure moving inboard, thus reducing bending stresses along the wing span. Because the ATLAS compensates for the increased wing root bending at elevated load factors, the overall effect of this modification is that the required reinforcement of the existing Cessna wing structure due to the winglet installation is reduced. The applicable airworthiness regulations do not contain adequate or appropriate safety standards for this design feature.

The ATLAS is not a primary flight control system, a trim device, or a wing flap. However, several regulations under Part 23, Subpart D—Design and Construction—Control Systems, have applicability to ATLAS, which might otherwise be considered “Not Applicable” under a strict interpretation of the regulations. These Control System regulations include §§ 23.672, 23.675, 23.677, 23.681, 23.683, 23.685, 23.693, 23.697, and 23.701.

An airplane designed with a load-relief system must provide an equivalent level of safety to an airplane with similar characteristics designed without a load-relief system. In the following special conditions, an equivalent level of safety is provided by relating the required structural safety factor to the probability of load-relief system failure and the probability of exceeding the frequency of design limit and ultimate loads.

These special conditions address several issues with the operation and failure of the load-relief system. These issues include the structural requirements for the system in the fully operational state; evaluation of the effects of system failure, both at the moment of failure and continued safe flight and landing with the failure annunciated to the pilot; and the potential for failure of the failure monitoring/pilot annunciation function.

The structural requirements for the load-relief system in the fully operational state are stated in special condition 2(e) of these special conditions. In this case, the structure must meet the full requirements of part 23, subparts C and D with full credit given for the effects of the load-relief system.

In the event of a load-relief system failure in-flight, the effects on the structure at the moment of failure must be considered as described in special condition 2(f)(1) of these special conditions. These effects include, but are not limited to the structural loads induced by a hard-over failure of the load-relief control surface and oscillatory system failures that may excite the structural dynamic modes. In evaluating these effects, pilot corrective actions may be considered and the airplane may be assumed to be in 1g (gravitation force) flight prior to the load-relief system failure. These special conditions allows credit, in the form of reduced structural factors of safety, based on the probability of failure of the load-relief system. Effects of an in-flight failure on flutter and fatigue and damage tolerance must also be evaluated.

Following the initial in-flight failure, the airplane must be capable of continued safe flight and landing. Special condition 2(f)(2) in these special conditions assumes that a properly functioning, monitoring, and annunciating system has alerted the pilot to the load-relief failure. Since the pilot has been made aware of the load-relief failure, appropriate flight limitations, including speed restrictions, may be considered when evaluating structural loads, flutter, and

fatigue and damage tolerance. These special conditions allows credit, in the form of reduced structural factors of safety, based on the probability of failure of the load-relief system and the flight time remaining on the failure flight.

Special condition 2(g) of these special conditions addresses the failure of the load-relief system to annunciate a failure to the pilot. These special conditions address this concern with maintenance actions and requirements for monitoring and annunciation systems.

These special conditions have been modified from previous, similar part 25 special conditions because of the differences between parts 23 and 25 as well as to address the part 91 operating and maintenance environment. Paragraph (c)(3) of the part 25 special condition¹ is removed from these special conditions. Special condition 2(h) of these special conditions is modified to require a ferry permit for additional flights after an annunciated failure or obvious system failure.

Type Certification Basis

Under the provisions of § 21.101, Cranfield Aerospace Limited must show that the Cessna model 525, as changed, continues to meet the applicable provisions of the regulations incorporated by reference in Type Certificate No. A1WI, revision 24, or the applicable regulations in effect on the date of application for the change. The regulations incorporated by reference in the type certificate are commonly referred to as the "original type certification basis." The regulations incorporated by reference in Type Certificate No. A1WI, revision 24 are 14 CFR part 23 effective February 1, 1965, amendments 23-1 through 23-38 and 23-40.

¹ Special Condition No. 25-164-SC, "Boeing Model 737-700 IGW, Interaction of Systems and Structures," Effective August 30, 2000 (65 FR 55443)

If the Administrator finds the applicable airworthiness regulations (i.e., 14 CFR part 23) do not contain adequate or appropriate safety standards for the Cessna model 525 because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16.

In addition to the applicable airworthiness regulations and special conditions, the Cessna 525 must comply with the fuel vent and exhaust emission requirements of 14 CFR part 34 and the noise certification requirements of 14 CFR part 36.

The FAA issues special conditions, as defined in 14 CFR 11.19, in accordance with § 11.38, and they become part of the type-certification basis under § 21.101.

Special conditions are initially applicable to the model for which they are issued. Should the applicant apply for a supplemental type certificate to modify any other model included on the same type certificate to incorporate the same or similar novel or unusual design feature, the FAA would apply these special conditions to the other model under § 21.101.

Novel or Unusual Design Features

The Cessna model 525 will incorporate the following novel or unusual design features:
Cranfield winglets with a Tamarack Active Technology Load Alleviation System

Discussion

For airplanes equipped with systems that affect structural performance, either directly or as a result of a failure or malfunction, the applicant must take into account the influence of these systems and their failure conditions when showing compliance with the requirements of part 23, subparts C and D.

The applicant must use the following criteria for showing compliance with these special conditions for airplanes equipped with flight control systems, autopilots, stability augmentation systems, load alleviation systems, flutter control systems, fuel management systems, and other

systems that either directly or as a result of failure or malfunction affect structural performance. If these special conditions are used for other systems, it may be necessary to adapt the criteria to the specific system.

Discussion of Comments

Notice of proposed special conditions No. 23-16-03-SC for the Cessna model 525 airplane was published in the Federal Register on November 22, 2016 (81 FR 83737). No comments were received, and the special conditions are adopted as proposed.

Applicability

As discussed above, these special conditions are applicable to the Cessna model 525. Should Cranfield Aerospace Limited apply at a later date for a supplemental type certificate to modify any other model included on A1WI, revision 24 to incorporate the same novel or unusual design feature, the FAA would apply these special conditions to that model as well.

Under standard practice, the effective date of final special conditions would be 30 days after the date of publication in the Federal Register; however, as the supplemental type certification date for the Cessna model 525 is imminent, the FAA finds that good cause exists to make these special conditions effective upon issuance.

Conclusion

This action affects only certain novel or unusual design features on one model of airplanes. It is not a rule of general applicability and it affects only the applicant who applied to the FAA for approval of these features on the airplane.

List of Subjects in 14 CFR Part 23

Aircraft, Aviation safety, Signs and symbols.

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 14 CFR 21.16, 21.101; and 14 CFR 11.38 and 11.19.

The Special Conditions

Accordingly, pursuant to the authority delegated to me by the Administrator, the following special conditions are issued as part of the type certification basis for Cessna Aircraft Company 525 airplanes modified by Cranfield Aerospace Limited.

1. Active Technology Load Alleviation System (ATLAS).

SC 23.672 Load Alleviation System

The load alleviation system must comply with the following:

(a) A warning, which is clearly distinguishable to the pilot under expected flight conditions without requiring the pilot's attention, must be provided for any failure in the load alleviation system or in any other automatic system that could result in an unsafe condition if the pilot was not aware of the failure. Warning systems must not activate the control system.

(b) The design of the load alleviation system or of any other automatic system must permit initial counteraction of failures without requiring exceptional pilot skill or strength, by either the deactivation of the system or a failed portion thereof, or by overriding the failure by movement of the flight controls in the normal sense.

(1) If deactivation of the system is used to counteract failures, the control for this initial counteraction must be readily accessible to each pilot while operating the control wheel and thrust control levers.

(2) If overriding the failure by movement of the flight controls is used, the override capability must be operationally demonstrated.

(c) It must be shown that, after any single failure of the load alleviation system, the airplane must be safely controllable when the failure or malfunction occurs at any speed or altitude within the approved operating limitations that is critical for the type of failure being considered;

(d) It must be shown that, while the system is active or after any single failure of the load alleviation system—

(1) The controllability and maneuverability requirements of part 23, subpart D, are met within a practical operational flight envelope (e.g., speed, altitude, normal acceleration, and airplane configuration) that is described in the Airplane Flight Manual (AFM); and

(2) The trim, stability, and stall characteristics are not impaired below a level needed to permit continued safe flight and landing.

SC 23.677 Load Alleviation Active Control Surface

(a) Proper precautions must be taken to prevent inadvertent or improper operation of the load alleviation system. It must be demonstrated that with the load alleviation system operating throughout its operational range, a pilot of average strength and skill level is able to continue safe flight with no objectionable increased workload.

(b) The load alleviation system must be designed so that, when any one connecting or transmitting element in the primary flight control system fails, adequate control for safe flight and landing is available.

(c) The load alleviation system must be irreversible unless the control surface is properly balanced and has no unsafe flutter characteristics. The system must have adequate rigidity and reliability in the portion of the system from the control surface to the attachment of the irreversible unit to the airplane structure.

(d) It must be demonstrated the airplane is safely controllable and a pilot can perform all maneuvers and operations necessary to affect a safe landing following any load alleviation system runaway not shown to be extremely improbable, allowing for appropriate time delay after pilot recognition of the system runaway. The demonstration must be conducted at critical airplane weights and center of gravity positions.

SC 23.683 Operation tests

(a) It must be shown by operation tests that, when the flight control system and the load alleviation systems are operated and loaded as prescribed in paragraph (c) of this section, the flight control system and load alleviation systems are free from—

- (1) Jamming;
- (2) Excessive friction; and
- (3) Excessive deflection.

(b) The operation tests in paragraph (a) of this section must also show the load alleviation system and associated surfaces do not restrict or prevent aileron control surface movements, or cause any adverse response of the ailerons, under the loading prescribed in paragraph (c) of this section that would prevent continued safe flight and landing.

(c) The prescribed test loads are for the entire load alleviation and flight control systems, loads corresponding to the limit air loads on the appropriate surfaces.

Note: Advisory Circular (AC) 23-17C “Systems and Equipment Guide to Certification of Part 23 Airplanes” provides guidance on potential methods of compliance with this section and other regulations applicable to this STC project.

SC 23.685 Control system details

(a) Each detail of the load alleviation system and related moveable surfaces must be designed and installed to prevent jamming, chafing, and interference from cargo, passengers, loose objects, or the freezing of moisture.

(b) There must be means in the cockpit to prevent the entry of foreign objects into places where they would jam any one connecting or transmitting element of the load alleviation system.

(c) Each element of the load alleviation system must have design features, or must be distinctively and permanently marked, to minimize the possibility of incorrect assembly that could result in malfunctioning of the control system.

SC 23.697 Load Alleviation System Controls

(a) The load alleviation control surface must be designed so that during normal operation, when the surface has been placed in any position, it will not move from that position unless the control is adjusted or is moved by the operation of a load alleviation system.

(b) The rate of movement of the control surface in response to the load alleviation system controls must give satisfactory flight and performance characteristics under steady or changing conditions of airspeed, engine power, attitude, flap configuration, speedbrake position, and during landing gear extension and retraction.

SC 23.701 Load Alleviation System Interconnection

(a) The load alleviation system and related movable surfaces as a system must—

(1) Be synchronized by a mechanical interconnection between the movable surfaces or by an approved equivalent means; or

(2) Be designed so the occurrence of any failure of the system that would result in an unsafe flight characteristic of the airplane is extremely improbable; or

(b) The airplane must be shown to have safe flight characteristics with any combination of extreme positions of individual movable surfaces.

(c) If an interconnection is used in multiengine airplanes, it must be designed to account for unsymmetrical loads resulting from flight with the engines on one side of the plane of symmetry inoperative and the remaining engines at takeoff power. For single-engine airplanes, and multiengine airplanes with no slipstream effects on the load alleviation system, it may be assumed that 100 percent of the critical air load acts on one side and 70 percent on the other.

Sections 23.675, “Stops;” 23.681, “Limit Load Static Tests;” and 23.693, “Joints”

The load alleviation system must comply with §§ 23.675, 23.681, and 23.693 as written and no unique special condition will be required for these regulations.

Applicability of Control System Regulations to Other Control Systems

If applicable, other control systems used on the Cessna 525 may require a showing of compliance to §§ 23.672, 23.675, 23.677, 23.681, 23.683, 23.685, 23.693, 23.697 and 23.701 as written for this STC project.

2. Interaction of systems and structures.

(a) The criteria defined herein only address the direct structural consequences of the system responses and performances and cannot be considered in isolation but should be included in the overall safety evaluation of the airplane. These criteria may in some instances duplicate standards already established for this evaluation. These criteria are only applicable to structure whose failure could prevent continued safe flight and landing. Specific criteria that define acceptable limits on handling characteristics or stability requirements when operating in the system degraded or inoperative mode are not provided in this special condition.

(b) Depending upon the specific characteristics of the airplane, additional studies may be required that go beyond the criteria provided in this special condition in order to demonstrate the capability of the airplane to meet other realistic conditions such as alternative gust or maneuver descriptions for an airplane equipped with a load alleviation system.

(c) The following definitions are applicable to this special condition.

(1) Structural performance: Capability of the airplane to meet the structural requirements of 14 CFR part 23.

(2) Flight limitations: Limitations that can be applied to the airplane flight conditions following an in-flight occurrence and that are included in the flight manual (e.g., speed limitations, avoidance of severe weather conditions, etc.).

(3) [Reserved]

(4) Probabilistic terms: The probabilistic terms (probable, improbable, extremely improbable) used in this special condition are the same as those used in § 23.1309. For the purposes of this special condition, extremely improbable for normal, utility, and acrobatic category airplanes is defined as 10^{-8} per hour. For commuter category airplanes, extremely improbable is defined as 10^{-9} per hour.

(5) Failure condition: The term failure condition is the same as that used in § 23.1309, however this special condition applies only to system failure conditions that affect the structural performance of the airplane (e.g., system failure conditions that induce loads, change the response of the airplane to inputs such as gusts or pilot actions, or lower flutter margins).

(d) **General.** The following criteria (paragraphs (e) through (i)) will be used in determining the influence of a system and its failure conditions on the airplane structure.

(e) **System fully operative.** With the system fully operative, the following apply:

(1) Limit loads must be derived in all normal operating configurations of the system from all the limit conditions specified in subpart C (or defined by special condition or equivalent level of safety in lieu of those specified in subpart C), taking into account any special behavior of such a system or associated functions or any effect on the structural performance of the airplane that may occur up to the limit loads. In particular, any significant nonlinearity (rate of displacement of control surface, thresholds or any other system nonlinearities) must be accounted for in a realistic or conservative way when deriving limit loads from limit conditions.

(2) The airplane must meet the strength requirements of part 23 (static strength and residual strength for failsafe or damage tolerant structure), using the specified factors to derive ultimate loads from the limit loads defined above. The effect of nonlinearities must be investigated beyond limit conditions to ensure the behavior of the system presents no anomaly compared to the behavior below limit conditions. However, conditions beyond limit conditions need not be considered when it can be shown that the airplane has design features that will not allow it to exceed those limit conditions.

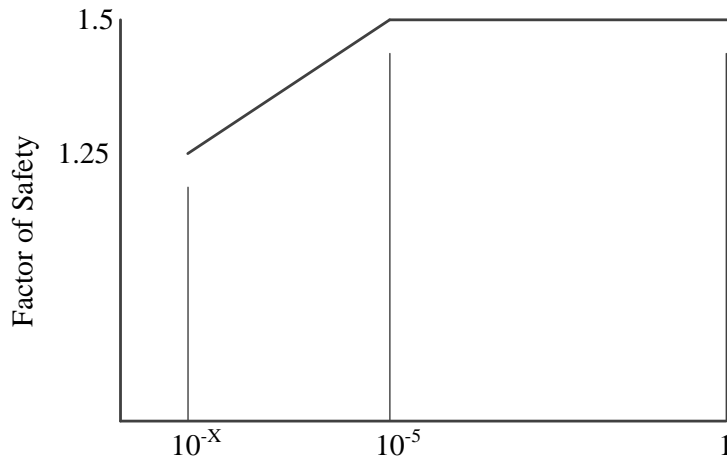
(3) The airplane must meet the aeroelastic stability requirements of § 23.629.

(f) **System in the failure condition.** For any system failure condition not shown to be extremely improbable, the following apply:

(1) At the time of occurrence. Starting from 1-g level flight conditions, a realistic scenario, including pilot corrective actions, must be established to determine the loads occurring at the time of failure and immediately after failure.

(i) For static strength substantiation, these loads, multiplied by an appropriate factor of safety that is related to the probability of occurrence of the failure, are ultimate loads to be considered for design. The factor of safety is defined in figure 1.

Figure 1—Factor of Safety at the Time of Occurrence



P_j , Probability of occurrence of failure mode j (per hour)

$10^{-X} = 10^{-8}$ for Normal, Utility, and Acrobatic Category Airplanes

$= 10^{-9}$ for Commuter Category Airplanes

(ii) For residual strength substantiation, the airplane must be able to withstand two thirds of the ultimate loads defined in subparagraph (f)(1)(i).

(iii) For pressurized cabins, these loads must be combined with the normal operating differential pressure.

(iv) Freedom from aeroelastic instability must be shown up to the speeds defined in § 23.629(f). For failure conditions that result in speeds beyond V_D/M_D , freedom from aeroelastic instability must be shown to increased speeds, so that the margins intended by § 23.629(f) are maintained.

(v) Failures of the system that result in forced structural vibrations (oscillatory failures) must not produce loads that could result in detrimental deformation of primary structure.

(2) For the continuation of the flight. For the airplane, in the system failed state and considering any appropriate reconfiguration and flight limitations, the following apply:

(i) The loads derived from the following conditions (or defined by special condition or equivalent level of safety in lieu of the following conditions) at speeds up to V_C / M_C , or the speed limitation prescribed for the remainder of the flight, must be determined:

(A) The limit symmetrical maneuvering conditions specified in §§ 23.321, 23.331, 23.333, 23.345, 23.421, 23.423, and 23.445.

(B) The limit gust and turbulence conditions specified in §§ 23.341, 23.345, 23.425, 23.443, and 23.445.

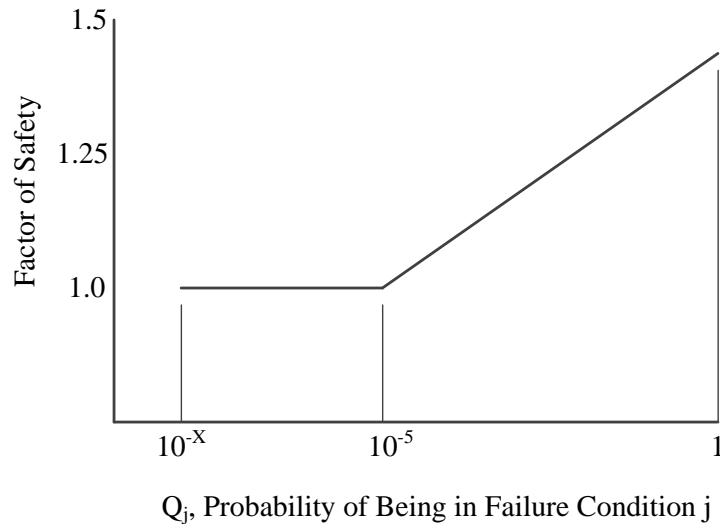
(C) The limit rolling conditions specified in § 23.349 and the limit unsymmetrical conditions specified in §§ 23.347, 23.427, and 23.445.

(D) The limit yaw maneuvering conditions specified in §§ 23.351, 23.441, and 23.445.

(E) The limit ground loading conditions specified in §§ 23.473 and 23.493.

(ii) For static strength substantiation, each part of the structure must be able to withstand the loads in paragraph (f)(2)(i) of this special condition multiplied by a factor of safety depending on the probability of being in this failure state. The factor of safety is defined in figure 2.

Figure 2—Factor of Safety for Continuation of Flight



$10^{-X} = 10^{-8}$ for Normal, Utility, and Acrobatic Category Airplanes
 $= 10^{-9}$ for Commuter Category Airplanes

$Q_j = (T_j)(P_j)$ where:

T_j = Average time spent in failure condition j , hours

P_j = Probability of occurrence of failure mode j , per hour

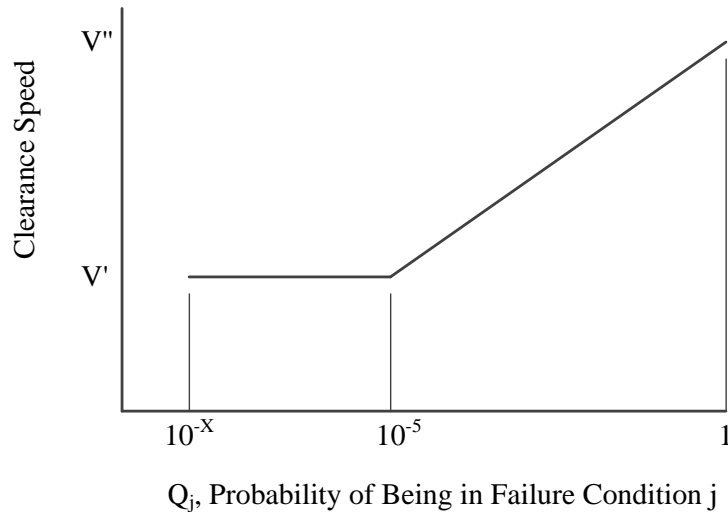
Note: If P_j is greater than 10^{-3} per flight hour then a 1.5 factor of safety must be applied to all limit load conditions specified in part 23 subpart C.

(iii) For residual strength substantiation, the airplane must be able to withstand two thirds of the ultimate loads defined in paragraph (f)(2)(ii) of this special condition. For pressurized cabins, these loads must be combined with the normal operating pressure differential.

(iv) If the loads induced by the failure condition have a significant effect on fatigue or damage tolerance then their effects must be taken into account.

(v) Freedom from aeroelastic instability must be shown up to a speed determined from figure 3. Flutter clearance speeds V' and V'' may be based on the speed limitation specified for the remainder of the flight using the margins defined by § 23.629.

Figure 3—Clearance Speed



$10^{-X} = 10^{-8}$ for Normal, Utility, and Acrobatic Category Airplanes
 $= 10^{-9}$ for Commuter Category Airplanes

$V' =$ Clearance speed as defined by §23.629(f)

$V'' =$ Clearance speed as defined by §23.629(b)

$Q_j = (T_j)(P_j)$ where:

$T_j =$ Average time spent in failure condition j, hours

$P_j =$ Probability of occurrence of failure mode j, per hour

Note: If P_j is greater than 10^{-3} per flight hour then the flutter clearance speed must not be less than V''

(vi) Freedom from aeroelastic instability must also be shown up to V' in figure 3 above, for any probable system failure condition combined with any damage required or selected for investigation by §§ 23.571 through 23.574.

(3) Consideration of certain failure conditions may be required by other sections of 14 CFR part 23 regardless of calculated system reliability. Where analysis shows the probability of these failure conditions to be less than 10^{-8} for normal, utility, or acrobatic category airplanes or less than 10^{-9} for commuter category airplanes, criteria other than those specified in this paragraph may be used for structural substantiation to show continued safe flight and landing.

(g) **Failure indications.** For system failure detection and indication, the following apply:

(1) The system must be checked for failure conditions, not extremely improbable, that degrade the structural capability below the level required by part 23 or significantly reduce the reliability of the remaining system. As far as reasonably practicable, the flightcrew must be made aware of these failures before flight. Certain elements of the control system, such as mechanical and hydraulic components, may use special periodic inspections, and electronic components may use daily checks, in lieu of detection and indication systems to achieve the objective of this requirement. These certification maintenance requirements must be limited to components that are not readily detectable by normal detection and indication systems and where service history shows that inspections will provide an adequate level of safety.

(2) The existence of any failure condition, not extremely improbable, during flight that could significantly affect the structural capability of the airplane and for which the associated reduction in airworthiness can be minimized by suitable flight limitations, must be signaled to the flightcrew. The probability of not annunciating these failure conditions must be extremely improbable (unannunciated failure). For example, failure conditions that result in a factor of safety between the airplane strength and the loads of subpart C below 1.25, or flutter margins below V'' , must be signaled to the flightcrew during flight.

(h) **Further flights with known load-relief system failure.** Additional flights after an annunciated failure of the load-relief system or obvious failure of the load-relief system are permitted with a ferry permit only. In these cases, ferry permits may be issued to allow moving the airplane to an appropriate maintenance facility. Additional flights are defined as, further flights after landing on a flight where an annunciated or obvious failure of the load-relief system has occurred or after an annunciated or obvious failure of the load-relief system occurs during preflight preparation.

(i) **Fatigue and damage tolerance.** If any system failure would have a significant effect on the fatigue or damage evaluations required in §§ 23.571 through 23.574, then these effects must be taken into account.

Issued in Kansas City, Missouri on December 23, 2016.

Barry Ballenger

Acting Manager, Small Airplane Directorate

Aircraft

Certification

Service

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